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COMMON DISEASES OF COLORADO TRUCK CROPS

BY L. W. DURRELL AND E. L. LECLERG

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COMMON DISEASES OF COLORADO TRUCK CROPS

By L. W. Durrell and E. L. LeClerg

The truck crops of Colorado are subject to several diseases which frequently cause considerable loss. Often the grower is not aware of the nature or seriousness of the disease until too late for successful control, or he may become alarmed at the appearance of a disease which is not of serious nature.

In this bulletin the diseases of truck crops most common to the state are listed under the crop-plant attacked and a brief description is given of each disease with the methods that may be used in its control.

DIRECTIONS FOR SENDING PLANTS FOR IDENTIFICATION

1. Send plenty of material. Send roots, stems and leaves of a diseased plant. It is difficult to properly identify a disease in many cases from fragments of a plant.
2. When sending soft-tissue plants, press out the leaves and wrap in oiled paper or moist newspaper, and then heavy dry wrapping paper, or put in a box and mail as soon after gathering as possible. In this way plants will arrive in good condition. Do not crowd a wad of the plant into an envelope for sending. Such material always arrives in poor condition and it is difficult or even impossible to identify.
3. When sending specimens of woody plants collect material which shows not only the diseased portion, but adjacent healthy parts.
4. Send all material to—

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Asparagus

Asparagus Rust is caused by a fungus.* The most common symptom of the disease is the browning or reddening of clumps of the smaller branches. The discolored areas spread rapidly until finally the entire plant appears as if it had ripened prematurely. A close examination shows that the red color is due to the stems being covered with small pustules of rust. These pustules contain the red spores or seeds of the rust which are readily blown by the wind from plant to plant and start new infections. These red pustules gradually give place to dark-colored ones, as the season advances. The black pustules contain the black winter spores of the rust organism. In this form the disease lives over

* *Puccinia asparagi*

winter. Early in the spring the black winter spores germinate and infect the young asparagus shoots producing a third type of spore in large round or oval yellow spots on the base of the stem. These in turn produce the red rust stage first described above.

The rust is favored by moisture. Good aeration of the soil should therefore be provided for the growing plant, thus permitting the dew or other moisture to dry quickly. As the disease spreads from plant to plant all old plants and trash as well as stray plants in fence corners and waste places should be destroyed. Very desirable resistant varieties of asparagus are now on the market, such as Martha Washington and Mary Washington. These are but slightly susceptible and their use offers a satisfactory remedy for asparagus rust.

Bean

Bean Blight [1].—Blight is caused by a bacterial organism and all of the above-ground parts of the bean plant are susceptible. This disease is very noticeable on the leaves, where it forms water-soaked or wilted areas, which soon enlarge and yellow and as they do so the affected tissue dies and turns brown. The center of the dead tissue often becomes thin and papery. (Fig 1). Badly diseased plants lose their leaves early and fail to mature seed.

Fairly large spots are also formed on the pods. These blotches are similar to those on the leaf, frequently starting as water-soaked areas or as brownish centers with red or yellow margins. The tissue does not shrivel or dry as it does in the leaf (Fig. 2). Diseased seed may appear shriveled or discolored, tho discoloration is not always evident.

Blight is carried over winter in the seed and seed should, therefore, be obtained from fields known to have been free from the disease. Disease-free seed cannot be selected from threshed seed. Crop rotation should be practiced if the disease becomes established in a field. For further precaution destroy all refuse from the bean field. Field inspection is necessary to insure clean seed.

Bean Rust [2].—This disease is caused by a rust fungus similar to that causing rust in asparagus or on grain. The term rust, however, is often wrongly applied to the above described bean blight. Bean rust appears as small brown pustules the size of a pinhead which are most numerous on the under sides of the leaves (Fig. 3), less abundant on the pods and occurs sparingly on

1 *Bacterium phaseoli*
2 *Uromyces appendiculatus*

Fig. 1.—Blight on the leaves of beans

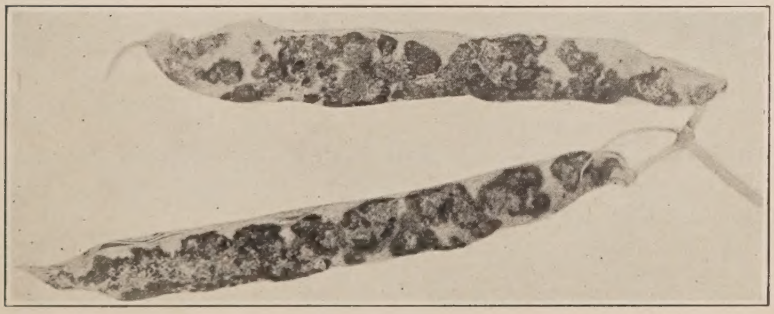

Fig. 2.—Water-soaked areas on bean pods caused by blight

the stems. When mature they break open and discharge a brown, powdery mass of spores which are distributed by the wind to other plants causing new infection. The disease, like all the rusts, is favored by moisture, rain or dew causing the rust spores to germinate and infect new plants. The leaves may have hundreds

Fig. 3.—Rust on leaf of bean

of these brown pustules on them and become shriveled and fall from the plant. In the case of a heavy rust attack, most of the vines in a field may be defoliated.

As the disease winters over on the dead plants, the destruction of these by burning offers the best means of combatting the disease. Spraying or dusting for rust is not successful. Several beans are as a rule more susceptible than the bush varieties and

varieties of beans are known to be somewhat resistant. The pole the wax-pod bush varieties are generally more resistant than the green-pod strains. None of our field varieties has been found resistant to bean rust.

Cabbage

Black-leg of Cabbage [3].—The earliest symptoms may appear in the seed-bed two or three weeks before transplanting time. Here infection frequently occurs on the stem near the surface of the ground, causing dark sunken irregular areas. Infection may occur later on older plants in the field, appearing as cankers on the stem. In the center of these spots are produced the fruiting bodies of the fungus, which appear as small, black specks, containing hundreds of spores that may be carried by insects or the spattering rain and wind to other plants. From these cankers the disease spreads, gradually killing the base of the stem and root so that the plant wilts and dies. (Fig. 4). Such wilting is characteristic of the advanced stages of this disease and the leaves adhere to the stem, instead of falling off. When the stem and roots decay late in the season the weight of the head causes the plant to lean or fall over. On the leaves the disease appears as rounded spots, whitish in the center and bearing the small black fruiting bodies of the fungus as in the case of the stem cankers.

Fig. 4.—Black-leg of cabbage. Arrow points to diseased area on stem at the ground line.

The disease lives in the cabbage refuse in the field and all diseased plants should be destroyed. A rotation of at least three years should be practiced and care should be exercised in transplanting seedlings to see that diseased plants are not planted in the field. If a field is infected the disease can be spread to other

[3] Caused by a fungus known as *Phoma lingum*

fields by tools. Manure from animals fed diseased cabbage leaves may also be a source of soil infection.

Treating cabbage seed with mercuric chloride or corrosive sublimate solution will reduce the disease. The seed should be soaked 20 minutes in a solution of corrosive sublimate, one oz. to eight gallons of water. The solution should be made up in a wooden, earthenware or glass container as the mercury will combine with a metal container. About 1/4 lb. of seed should be placed in a small cheese-cloth bag when dipped in this solution. Larger amounts do not become uniformly treated. Wash the seed in clean water after treating and spread out to dry.

Celery

Late Blight of Celery [4].—This disease is the most common one on celery in Colorado and appears as small circular yellow or brown spots on the leaves and stems (Fig 5). In the center of these spots develop small fruiting bodies of the fungus that may be seen as minute black specks. From these bodies large numbers of spores are developed that can be blown by the wind, spattered by rain, or carried by tools or on the clothes of field workers to other plants and there start new disease spots. In cases of severe infection the leaves brown and die and the stems wilt. Because of this brown appearance the disease is often wrongly called rust. In storage the diseased spots furnish entrance for various rots which often cause serious losses. The disease is favored by moisture and is more prevalent in low damp places in the field.

The disease lives over winter on the old dead celery leaves and trash and may also be carried by the seed. All the trash in the field should be destroyed, especially if rotation cannot be practiced. Trimmings from diseased plants should not be left in the field but destroyed or composted thoroly.

Spraying with Bordeaux mixture 5-5-50 or dusting with copper lime dust 20-80 is the most satisfactory method of control for the disease. Apply the spray or dust to the seedlings in seedbed when about one inch tall and also just before transplanting. After the plants are well started in the field they should be sprayed or dusted every week until a week or two before harvest. Five applications during the growing season are usually enough.

Early Blight of Celery. In Colorado this disease may appear in June but seldom does much damage until July or August. The disease is caused by a fungus [5] which produces leaf spots

[4] Caused by the fungal organism *Septoria apii*
[5] *Cercospora apii*

Fig. 5.—Late blight of celery

similar to those of late blight. The spots, however, are large and more irregular, often having a water-soaked appearance (Fig. 6); in severe cases the leaves wilt and die.

The disease is spread in much the same way as late blight and is favored by moisture. In both early and late blight the control measures are the same. The destruction of old leaves and trash and rotation should be emphasized in combating these diseases.

Pink Rot.—Pink rot is caused by a fungus,[6] sometimes attacking celery in the field. It is more liable, however, to occur as a storage rot. The rot first appears pink, later becoming grey or brown and the diseased portions become soft. The organism

Fig. 6.—Early blight of celery

causing the disease also attacks carrots, lettuce, turnips, etc., and where celery is grown in rotation with these crops, infection of the soil is increased.

The disease is favored by excess moisture. Cultivation and aeration of the soil will tend to keep down the disease in the

6 *Sclerotinia libertiana*

field In storage a temperature of 30.5 degrees F or 31 degrees F will hold the disease in check; above 33 degrees F, rot will occur. The storage room should be well ventilated and dry.

Cucurbits

Powdery Mildew of Cucurbits.—Of the several diseases of our vine crops, powdery mildew is one of the most common, being particularly severe on pumpkins in this state. It is caused by a fungus[7] which grows over the surface of the leaves sending down numerous minute branches into the leaf cells, eventually killing the leaves.

The mildew is most prevalent in greenhouses, and in the field, in seasons of high temperature if sufficient moisture is present. It is first noticeable as dusty whitish spots on the younger leaves. These spots later enlarge and in a few weeks may spread to the entire plant. As the disease advances, many of the diseased leaves turn brown or die. It is spread by blowing and washing of the spores of the fungus from plant to plant. It lives over winter in the spore stage on old diseased leaves.

In greenhouses it can be controlled by dusting the plants with sulfur or by spraying with a solution of potassium sulfide. The latter spray, tho effective in killing the mildew, is liable to burn the younger leaves.

As yet no practical field control is known for this disease. The expense makes spraying or dusting impracticable.

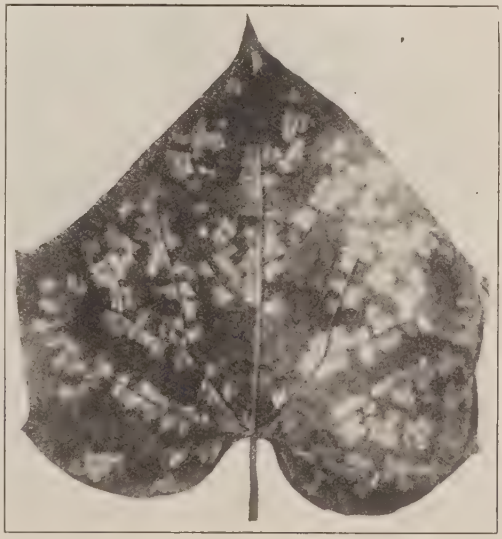

Fig. 7.—Angular leaf spot of cucurbits

Angular Leaf Spot.—This disease of cucurbits periodi-

[7] *Erysiphe cichoracearum*

cally occurs in the cucumber and melon patches of the state. It is caused by a bacterial organism[8] and occurs on all parts of the plant, first appearing as water-soaked angular spots particularly noticeable on the leaves and fruit. Frequently if weather is moist, small droplets ooze from the diseased spots. The diseased spots later die and turn grey, remaining angular and not increasing in size (Fig. 7). Moisture and high temperature favor the development and spread of leafspot.

Spraying with Bordeaux mixture 4-4-50 after the disease has started is of benefit in controlling the disease. Prevention of the disease by rotation of crops and by seed treatment are recommended as it may be borne by the seed. Soak the seed in a solution of corrosive sublimate, one ounce to eight gallons of water. Put the seed in small cheesecloth bags and soak for 10 minutes in the solution. Stir or agitate the seed while soaking so they are

Fig. 8.—Macrosporium blight of cucumber

[8] *Bacterium lachrymans*

thoroly wetted. Rinse in clean water and dry. Do not use a metal vessel to hold the corrosive sublimate.

Leaf Blight of Cucurbits[9].—This disease is frequently found on the leaves of muskmellons and other cucurbits. It appears on the older leaves as roundish water-soaked spots of varying size which soon die and turn brown. Several spots may run together and the dead centers become torn. (Fig. 8). Generally the disease appears late in the season and is not serious. It can be controlled by the same sprays as used for angular leaf spot.

Bacterial Wilt.—This wilt disease is caused by a bacterial organism[10] which plugs up the water-conducting tubes in the vine stems. The diseased vines first show a wilting of the young runners, but gradually the whole branch or entire plant wilts and dies (Fig. 9). The sap of the diseased plant is not watery, but abnormally sticky and stringy.

Similar symptoms may be caused by injury to the base of the

Fig. 9.—Bacterial wilt as the name indicates, wilts the ends of the vines and finally kills the entire plant.

9 Caused by the fungus *Macrosporium cucumerinum*
10 *Bacillus tracheiphilus*

plant by root rot or borers. The sap of the plant in these cases is not sticky and stringy.

The disease is carried by the striped and twelve-spotted beetles. The organism causing the disease is thought to live over winter in the hibernating beetles and these insects reinfect the young plants in the spring.

Control of this disease is very difficult as it is dependent on the control of the beetles. Where but a few plants are grown in a garden they can be protected by netting stretched over hoops with the edges covered with earth so the bettles cannot crawl under. In large plantings all trash harboring the bettles should be destroyed. A catch crop of squashes may be planted near the edge of the field, to attract the beetles where they can be destroyed. Plants showing wilt should be pulled and destroyed. If wilt has been known to occur in the field, the plants should be thoroly dusted as soon as they sprout above the ground and sprayed or dusted every week thereafter. Several dusts have been used on the seedlings: Calcium arsenate 1 pound, gypsum 20 pounds or Paris green ½ pound; lead arsenate 1 pound and gypsum or lime 15 pounds. Another recommended mixture is black-leaf 40, 5 pounds, lead arsenate 15 pounds and gypsum or lime 80 pounds. The lime is somewhat injurious to the young seedlings. For treating older plants Bordeaux mixture 3-4-50 with 1½ pounds of powdered arsenate of lead may be used. In applying dusts or sprays care should be taken to get the chemical to the under side of the leaves.

Lettuce

Downy Mildew.—This mildew is unlike the powdery mildew of cucurbits and is caused by one of the "water molds."[11] The fungus causing the disease produces dead areas on the older leaves and there fruits in white glistening patches of spores easily seen with the naked eye. The diseased leaves become yellow and die at the margins and the heads sometimes are dwarfed. (Fig. 10). The disease is favored by moisture and cool weather and is thought to live over from season to season on wild lettuce. In shipping, the moist condition of the leaves and the temperature of the cars often result in heavy loss from the mildew, as a few diseased plants may infect a number of crates. Soft rots usually follow the mildew, reducing the outer leaves to a slimy mass.

In the greenhouse the disease can be controlled by regulation of temperature and watering and by spraying the young plants

11 *Bremia lactucae*

Fig. 10.—Downy mildew of lettuce

with Bordeaux mixture. Most of the lettuce in this state is grown out of doors and under these conditions no specific control is known. The eradication of the wild host plants however and rotation of crops would materially check the disease.

Onions

Smut [12].—This disease appears as dark streaks on the leaves, stems and bulbs of the onion and starts when the first leaf appears. The plants become stunted and the leaves twisted (Fig. 11). The dark streaks break open exposing a black smutty mass of spores of the fungus. Many of the seedlings die from the attack and soft rot often follows the smut injury.

The smut gains entrance to the plant in the seedling stage. Onion sets, however, are immune and in small plantings these may be used to insure freedom from smut.

In field plantings smut may be controlled by the use of a solution of formaldehyde, one pint to 16 gallons of water, dripped into the furrow with the seed when planted. About 200 gallons

12 Caused by the fungus *Urocystis cepulae*

Fig. 11.—Onion smut

of this solution are required for an acre. Somewhat less than this is required if the soil is wet. A tank of one to several gallons capacity may be fastened to the seeder and the formaldehyde dripped into the furrow with the seed thru a small pipe of about 5/16 inch bore. The pipe should be fitted with a stopcock to shut off or regulate the flow.

Onion Mildew [13].—This disease usually comes late in the season and attacks the leaves, forming a purplish mold on the surface The leaves also take on a water-soaked appearance and later become yellow and dry. New leaves that are put out may become attacked. The disease is favored by humid weather. It lives over winter in bulbs and sets, also in the old dead leaves left on the ground

Control of this disease is not well worked out. Spraying is not practical as the disease usually appears suddenly when it is too late to spray. Rotation of crops and planting in well-drained soil are helpful in preventing the disease Trees, wind breaks and weeds prevent the soil from drying and furnish favorable conditions for its development. All trash should be destroyed.

Onion Smudge.—This disease appears as black blotches on the scales of the onion bulbs. It is also caused by a fungus [14] and the chief injury is the discoloration which injures the appearance of the onion and lowers its sale value. It chiefly attacks the white varieties, the loss to the red or yellow onions being slight.

The fungus causing smudge grows best in wet soil at high temperatures. No control is known tho general precautions of rotation and sanitation are recommended.

Neck Rot.—The neck rot of onions is a disease caused by a fungus [15] which attacks chiefly the mature onion, causing a rotting of the neck and bulb. The rotten areas appear yellowed and sunken, and between the scales of the bulbs are produced masses of felty-grey mold. The disease usually affects the onions in storage tho sometimes they may be attacked while still in the ground. As the disease progresses the fungus causing it develops hard, black, crusty masses known as sclerotia. These live over winter and start infection the following year.

The disease seldom affects onions in dry, well-ventilated storage houses. The onions should be well dried before storage and kept at about 32 degrees F. Fumigation has little effect on the mold and may injure the onions.

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13 Caused by one of the downy mildews *Peronospora schleideni*
14 *Colletotrichum circinans*
15 *Botrytis allii*

Peas

Root Rot of Peas is caused by a fungus [16] which lives in the soil for years and attacks the roots and base of the stem of peas causing a rotting off of these parts and subsequent wilting and death of the plant (Fig. 12). The fungus grows best at high temperatures and it may appear in spots in the field at any time the weather is favorable. Three other fungi are known to cause a similar root rot.[17]

Fig. 12—Peas affected with root rot showing wilted and dwarfed condition. Plants on the right are healthy

As the organisms causing root rot live several years in the soil, no treatment is possible. Long rotations are, however, suggested as an aid in reducing the losses from the disease.

Powdery Mildew.—The powdery mildew [18] is very common on peas. It usually comes late and is seldom of any importance. It is readily recognized by the white powdery appearance it gives to the pea leaves. It can be remedied by spraying with Bordeaux or dusting with sulfur but the injury seldom, if ever, justifies treatment.

Potatoes

Black Scurf-Rhizoctonia.—This disease is of frequent occurrence, and is caused by a soil fungus.[19] This fungus also attacks the and lower stems of several other plants besides the potato. The

16 *Fusarium Martii var pisi*
17 *Pythium debaryanum, Corticum vagum*, and a species of *Aphanomyces*
18 Caused by *Erysiphe polygoni*
19 *Corticium vagum*

most common symptom of the disease is the development of black specks or flakes of the fungus on the skin of the mature tubers (Fig. 13). These specks look like dirt, but do not wash off. On the base of the stem of the mature plants the fungus frequently produces a grey felt-like growth, especially if the soil is moist (Fig. 14) Another symptom of the disease is the production of aerial tubers on the stems above ground (Fig. 15).

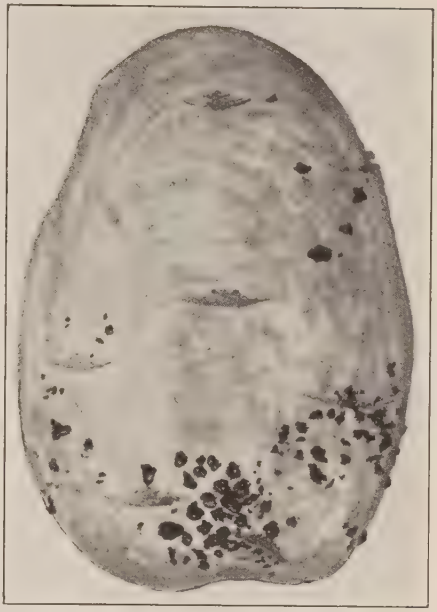

Fig. 13.—Rhizoctonia or black scurf of potatoes on the tuber

The most serious injury from the disease is the rotting off of the young sprouts. These may be rotted off as fast as produced so that the stand is reduced or the sprouts that do survive are weak. It is generally believed that wet, acid soils are favorable to the disease. As the disease lives in the soil, long rotations should be followed. Plant seed as free as possible from scurf and treat the seed with formalin or corrosive sublimate.

Hot Formaldehyde Treatment.—This treatment has been found effective for Rhizoctonia. It consists of dipping the tubers in a solution of one pint formaldehyde to 15 gallons of water, heated to 120° F. The water is kept hot by a stove or by live-steam pipes in the treating tank. The tubers are held in this hot solution for three minutes then removed and covered with sacks or tarpaulin for one hour, then spread out to dry. The formaldehyde solution is not poisonous and does not deteriorate rapidly like corrosive sublimate and it can be used in metal containers.

Corrosive Sublimate.—In this method of treating potatoes for black scurf four ounces of corrosive sublimate (mercuric chloride) are dissolved in a little hot water, then cold water is

Fig. 14.—Diseased potato roots showing the grey Rhizoctonia mold on the stems at ground line

added to make 30 gallons. The water should be not colder than 45° F. The solution is put in wooden tanks or barrels (never use metal tanks) and the potatoes are soaked in it for one hour and a half. They are then removed and spread out to dry. Each mixture of the solution is sufficient to treat three lots of potatoes. Dipping potatoes that are very dirty or dipping them in sacks is not advisable as the sacks or the dirt quickly decreases the strength of the treating solution.

Fig. 15.—Aerial tubers caused by Rhizoctonia

Common Scab.—Potato scab is such a well-known disease that its description is unnecessary. It is caused by an organism [20] which lives on humus in the soil and is most prevalent in alkaline soils. It is checked by acidity and the addition of lime tends to increase it.

The appearance of the disease is well known and is characterized by round corky pits on the skin of the potato. These vary from mere specks to deep irregular pits. Dry soil encourages scab formation and wet soil retards its development.

The plowing under of green manure tends to produce an acid condition in the soil unfavorable to scab. In badly infested soil the growing of smooth potatoes is difficult. Long rotations are

20 *Actinomyces scabies*

advisable to prevent the soil from becoming infested. The use of healthy, treated seed is the best means of controlling the disease.

The treatments recommended for black scurf are effective for common scab.

Tuber Rots.—The rotting of tubers in storage is caused by several species of fungi. These gain entrance to the tubers chiefly thru bruises. Improper storage conditions favor the growth of these fungi in the tubers. The first requirement for potatoes free of tuber rot is healthy vines in the field grown from selected or certified seed. Care should be used in handling the tubers at harvest to avoid bruising and cutting. The storage room should be clean and well ventilated, dry and near 38° F.

Seed selection and field inspection for certification cannot be too strongly recommended as a remedy for potato diseases.

Tomatoes

Leaf Spot.—This is one of the commonest diseases of tomatoes and is caused by a fungus.[21] The disease is characterized by small rounded spots on the leaves and sometimes on the stems. These spots first have a water-soaked appearance, later becoming brown or grey, bearing minute black fruiting bodies of the fungus. The disease may start in the seedbed or at any time after setting out the plants. The lower leaves are usually attacked first and the disease later spreads by wind, rain or other agents, to the upper leaves. In severe cases the plants yellow or may drop their leaves.

The destruction of old vines and trash in the field and rotation are material aids in checking the leaf-spot disease. Care should be taken to prevent the start of the disease in the seedbeds. Clean or sterilized soil should be used for the seedbed and any boards or covers on these beds should be washed in a blue vitriol solution. If the disease starts in the seedbed the plants should be sprayed with a 4-4-50 Bordeaux mixture. In general the disease appears late in the season and does not cause serious damage in the field. While it can be controlled in the field by Bordeaux mixture, the spray tends to cause later maturing of the vines. The slight increase in yield seldom justifies the use of sprays.

Leaf Mold.—This disease is chiefly a greenhouse trouble caused by a fungus.[22] The leaves and stems are chiefly attacked

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21 *Septoria lycopersici*
22 *Cladisporium fulvum*

by this fungus and appear first yellowed, then become covered with a dusty brown mass of the mold.

The disease is spread by pickers and by watering. High humidity also favors the disease. Good ventilation, plenty of sunshine and high temperature are important in decreasing its spread. Houses where the disease has appeared should be cleaned thoroly and all the old vines destroyed. Spraying with lime sulfur has been used as a control of this disease.

Mosaic

This disease affects several of our truck crops as well as a number of common weeds. Cucumbers, melons, tomatoes, potatoes, beans, lettuce and celery are all susceptible to the disease. The cause of the mosaic, however, is unknown.

The general symptom of the disease is a peculiar mottling of the leaves in irregular areas of dark and light green. The general tendency is toward stunting of growth and deformity of the leaves and fruit. The disease is highly infectious and is readily transmitted from plant to plant. Insects are ready carriers of the disease. Aphids or plant lice and cucumber beetles are active agents in spreading mosaic. In the case of potatoes it is generally believed that the disease is transmitted by the seed tubers. Roguing and field inspection are effective in reducing the disease in potatoes. The appearance of mosaic is to some extent influenced by weather conditions.

Mosaic on cucumbers and melons is largely dependent on insects present. Where the number of insects is kept down, spread of mosaic is reduced.

Mosaic is known to be harbored by several common weeds. Wild cucumber, milkweed and ground cherry may transmit mosaic to crop plants and should not be allowed to grow near garden or truck patches. Plant refuse or trash that harbors insects should be destroyed as a general precautionary measure. Mosaic can be transmitted thru the seed in several plants. Such transmittal has been reported in the case of peas, lettuce, common beans and lima beans.

There is no definite control for mosiac. Field inspection, roguing out of diseased plants, control of insects and destruction of such plants as milkweed, ground cherry and wild cucumber assist in reducing the disease.

Damping off.—A number of truck-crop plants are subject to damping-off. The disease affects the plants in the seedling stage causing them to rot off at the surface of the ground. The stems

appear water-soaked and soft and the plant collapses and falls over on the ground.

The disease is caused by several soil fungi, the most common and important of which is a water mold.[23] This fungus lives indefinitely in the soil and grows best in wet, warm soil. Damping-off usually occurs in seedbeds where the plants are crowded and the soil is too wet. Slow-drying soil and poor ventilation of the greenhouse or cold frames are conductive to the disease.

In controlling damping-off the first preventive measure is to get rid of surface moisture on the soil. Ventilation and spacing of plants or a thin layer of sand on the soil will tend to keep the surface of the soil dry and produce conditions unfavorable for the growth of the fungus.

Soil sterilization is effective in combating the disease; formaldehyde or heat may be used for this purpose.

The formaldehyde treatment consists of sprinkling the loosened soil with a solution of formaldehyde, one gallon to 50 gallons of water. Sprinkle one gallon of this solution to a square foot of the soil and then cover the plot for 12 hours. Planting should not be made in the soil for ten days after treating.

In a similar way copper sulphate or blue vitriol may be applied. One pound of the sulphate is dissolved in 25 gallons of water and applied at the rate of one pint to a square foot of ground. An equal amount of water should then be sprinkled on the soil to wash the copper into the ground.

Soil sterilization by heat is the most successful method of destroying the damping-off fungus. This can best be accomplished by turning live steam into an inverted iron pan over the seedbed. The soil is exposed to the steam for one-half to one and one-half hours. In testing the efficiency of the treatment, a potato may be buried in the soil four or five inches deep, the time necessary to cook the potato is enough to kill the damping-off fungus.

Steam pipes[24] buried in the soil at a depth of eight inches and two feet apart furnish a very satisfactory method of soil sterilization. The pipes are connected to a header or lead pipe direct from a boiler. Holes of about 5/16 inch diameter are bored in the pipes six inches apart and the steam escaping from these thoroly heats and sterlizes the soil. Smaller holes than 5/16 inch tend to plug up and prevent the escape of steam. A low-pressure boiler of large capacity is most suitable for this work. Steaming should continue for two hours.

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23 *Pythium debaryanum*
24 See Bul. 321, Colo. Agr. Exp. Sta.

FUNGICIDES

Methods of Preparation

1. Blue Vitriol-Copper Sulphate.—Copper has a very specific action on fungi and may be used in the form of copper sulphate for sterilizing coldframes, washing greenhouse walls and benches, etc.

Copper sulphate, 2 to 3 pounds.
Water, 50 gallons.
Dissolve the copper in a little hot water and then dilute to 50 gallons.

2. Bordeaux Mixture.—a. Home-made. This consists of blue vitriol, lump lime and hot water in the following proportions: Blue vitriol (copper sulphate) 4 pounds, unslaked hot lime 4 pounds, water 50 gallons. This is known as a 4-4-50 mixture. Other proportions for various diseases are recommended such as 3-3-50 or 5-5-50. Hydrated lime may be substituted for lump lime but 50 percent more must be used. The best way to prepare home-made bordeaux is to dissolve the blue vitriol in 25 gallons of water. The chemical dissolves quickest if suspended in a sack at the top of the barrel or tank holding the water. Slack the four pounds of lime in just enough water to slack it well and mix with 25 gallons of water. Pour the 25 gallons of blue vitriol solution and the 25 gallons of lime solution into a third barrel or tank simultaneously. This insures thoro mixing and gives an excellent suspension of the small lime particles.

b. Dry Bordeaux. This is a commercial preparation of lime and blue vitriol. It is dissolved in water direct from the package. Directions for mixing are found on the container. Dry bordeaux is very useful for gardens where but a small amount of spray material is needed.

c. Bordeaux dust. This is a commercial mixture of lime and blue vitriol prepared as a very fine dust. It is not to be mixed with water, but should be dusted on the plants with a blower. It has not been tested sufficiently to justify recommendation.

3. Corrosive Sublimate.—This chemical can be obtained at any drug store in tablets or in powdered form. When dissolved in water it is a very effective disinfectant. It is used for treating seed potatoes, cabbage, cucumber, muskmelon and tomato

seed. The usual formula is one to one thousand or one ounce of corrosive sublimate to eight gallons of water. In mixing use only wooden, glass or eathenware containers as it corrodes metal containers. ***CAUTION—Corrosive sublimate is a deadly poison.***

4. Formaldehyde.—This is a seed disinfectant and fumigant usually sold under the name of Formalin. The commercial material is a 40 percent solution of formaldehyde. It is used as a substitute for corrosive sublimate and is especially suitable for treating seed. The usual mixture is one pint of the commercial 40 percent formalin to 40 gallons of water. In treating potatoes it has been found to be more effective when heated to a temperature of 122° F. When used in sterilizing soil as in control for damping off, it should be made up one gallon to 50 gallons of water and the solution applied to the soil at the rate of one gallon of solution to one square foot of soil. Formalin becomes weaker on standing. In buying formalin only fresh material should be purchased. Old bottles that have stood for a year or two are liable to give unsatisfactory results.

5. Potassium Sulphide.—This chemical is effective in controlling the powdery mildews, altho it is not as effective as copper sprays for other fungi. It is prepared in the following proportions:

Potassium sulphide, 3 oz.
Water, 10 gallons.

The spray should be prepared fresh each time it is to be used. In the greenhouse a weaker mixture should be used on cucurbits as the above strength tends to burn the young leaves.

6. Sulfur.—(a) Flowers of sulfur. This is the ordinary yellow powdered sulfur obtainable at any drug store. It is a very effective fungicide, being particularly useful for the powdery mildews. It should be dusted on in the early morning when dew is present.

(b) Atomic sulfur. This is a commercial preparation, more finely powdered than the flowers of sulfur, and is also more effective. It may be mixed with water and used as a spray, as well as in the dust form. This dust is so fine that it tends to lump and clog without a filler. When lime is mixed with sulfur as a filler the proportion varies from 50 to 90 percent sulfur, the proportion depending on the severity of the disease.

7. ***Spreaders.*** Frequently fungicidal sprays do not stick well to plant leaves, but tend to collect in drops and run off. Several materials are useful to hold the spray on the leaves. These spreaders or stickers also tend to make the spray film thinner and are economical to use. Moreover, they hold the spray on the leaves for a longer time and prevent washing off by rain. Common laundry soap shaved up and dissolved in spray solution makes an effective sticker. Skimmilk has a similar effect, or commercial preparations of casein are very effective as spreaders.

NOTE: The approximate prices on the above mentioned substances are listed below.

Copper sulphate	$ .15	per	pound
Dry Bordeaux	.20	"	"
Corrosive sublimate	2.70	"	"
Formaldehyde	.24	"	"
Sulfur-flowers	.10	"	"
-rolled	.06	"	"
-precipitated	.35	"	"
Fish-oil soap	.25	"	"
Rosin	.15	"	"
Kaso	.20	"	"

*See Bul. 321, Colo. Agr. Exp. Sta.